Antarctic Digital Power Supply
Verification Document

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1. Introduction

The company we work for is considering to bid for the contract to supply 200 weather stations which involves some investment and commercial risk. We have been tasked with producing a voltage regulator , which would provide a dc power supply to an antarctic weather station to supply a stable 5V and 12V output with a maximum load current of 20mA. The solution should meet the requirement set by the client as well as fit within the constraints that have been set due to limited resources (lab resources).

2. Verification Matrix

Requirement number	Requirement	Verification Method	Responsible Person
1.	The DPS shall not suffer damage at temperatures down to -40°C	A	Krishan
2.	Will operate at -70°C	A	Krishan
3.	Power supply system should be less than 25g	I	Krishan
4.	System should have flying leads for the	I	Krishan

	connection to the battery		
5.	System should generate a maximum short circuit output current of 30mA on either output	T/D	Krishan
6.	Should have a power efficiency of over 60% *with 20mA current load on either of the two outputs	T/A	Ayush
7.	The digital power supply should have a voltage output between 4.85V-5.15V since the highest minimum and lowest maximum voltages for the modules are 4.85V and 5.15V respectively.	D	Nurul
8.	It should also have a voltage output between 11.2V-12.8V as it is within the range required for the FLASH memory. The output current here should be 20mA as the FLASH memory can handle this	D	Nurul
9.	The single input voltage should be at least 16.75V which should be able to power all modules	D	Nurul

	and this is not within +/- 10% of either output voltage making it suitable		
10.	The system should maintain the output voltage specifications with an input voltage of +/- 20% from the nominal	D/A/T	Nurul
11.	Must use DipTrace for designing the PCB which is free & for non-profit use	I	Nicholas
12.	The PCB board should be doubled sided with a through hole plate so components will only be placed on the top side.	I	Nicholas
13.	Surface mount components will be used (no thru-hole components) of the package type 0805 while surface mount inductors cannot be used	I	Nicholas
14.	Narrow range of regulators and DC-DC converters to choose from within the lab	I	Nicholas

15.	Board should have dimensions of 5cm x 5cm (a square)	I	Junaid
16.	The vias (vertical interconnect access) holes should be 0.8mm while the copper pads should be 1.6mm	I	Junaid
17.	The holes for attachment of the wires/test pins should be 1.00mm while the copper pads should be 1.8mm	I	Junaid
18.	The track width should be a minimum of 0.4mm	I	Junaid
19.	The track to track/track to pad separation should be a minimum of 0.4mm	I	Ayush
20.	The Copper pour spacing should be 1mm	I	Ayush
21.	The track/via/pad to board edge separation should have no tracks within 2mm of the edge	I	Ayush

22.	Group number to be written in copper on the board on the top-side along the top	I	Ayush

I = inspection, A = analysis, T = test, D = demonstration.

3. Verification Tests and Results

3.1 DPS will not suffer damage at temperatures down to -40°C (Analysis)

3.1.1 Verification Test

The data sheet of every component in the design will be checked to confirm that the specified storage temperature is -40°C or less. For the printed circuit board, the storage temperature of the unprocessed laminate sheet will be used.

3.1.2 Verification Result

The following table shows the minimum storage temperatures for each component in the design.

Component	**Minimum Storage Temperature (°C)**
uA723 Voltage regulator	-65
0805 SMD Resistors	-55
0805 SMD Capacitors	-55
PCB sheet	-55

3.2 Will operate at -70°C (Analysis)

3.2.1 Verification Test

The data sheet of every component will be checked to confirm the range of operation is within 0 - 70°C. The output voltage should remain within the desired specification over the temperature range of 0 - 70°C. Analysis will be done since it cannot be tested within the restrictions of lab. From the uA723 datasheet, there is a maximum variation of 0.015%/°C on the output voltage.

3.2.2 Verification Result

We can find the maximum possible variation in the output voltage using the temperature effects as shown below.

Output Voltage / V	Maximum Variation / V
5.0	+0.05
12.0	+0.13

3.3 Power supply system should be less than 25g (Inspection)

3.3.1 Verification Test

Knowing roughly the weight of a 25g, and by holding the PCB we can approximately get the weight of the PCB. If the PCB is much lighter than 25g or heavier it will be easier to tell , however if it is close to 25g, a decision cannot be made and a weighing scale will be used.

3.3.2 Verification Result

We found from inspection that the weight could easily be differentiated from 25g and found it was lighter than 25g at a weight of 10g including the flying leads.

3.4 System should have flying leads for the connection to the battery (Inspection)

3.4.1 Verification Test

Looking at the circuit we see if we find flying leads at the input terminal.

3.4.2 Verification Result

These were found soldered onto the board on the pads.

3.5 System should generate a maximum short circuit output current of 30mA on either output (Testing/Demonstration)

3.5.1 Verification Test

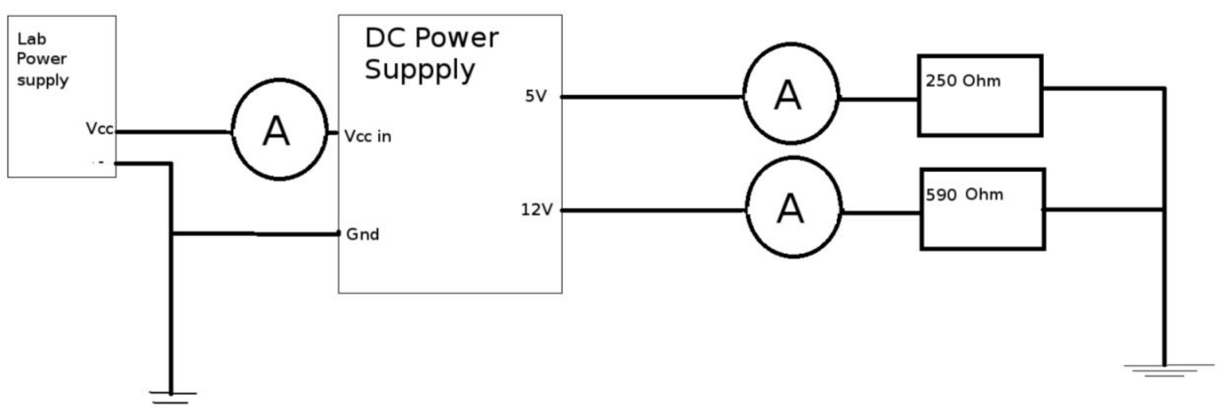
We connect the output to a breadboard and connect an ammeter in series with the output and the ground, which would all us to measure the current flowing through the output with no load (effectively 0Ω resistance).

3.5.2 Verification Result

When measuring we found that the output current during short circuit was 27mA which is controlled by the Rsc resistor (22Ω). The current limit is set by 0.65V/22Ω = 30mA.

3.6 Should have a power efficiency of over 60% with 20mA current load on either of the two outputs (Testing/Analysis)

3.6.1 Verification Test



Using the following circuit configuration we were able to drive 20 mA currents through the outputs of both the voltage sources. We also measured the current the DC power supply was drawing from the lab's power supply. We then used the formula efficiency = $[(5 \times I1 + 12 \times I2) \div (V cc * I3)]$ *100 where I1 is the current through the 250 ohm resistor

I2 is the current through the 590 ohm resistor and I3 is the current drawn from the lab's power supply.

3.6.2 Verification Result

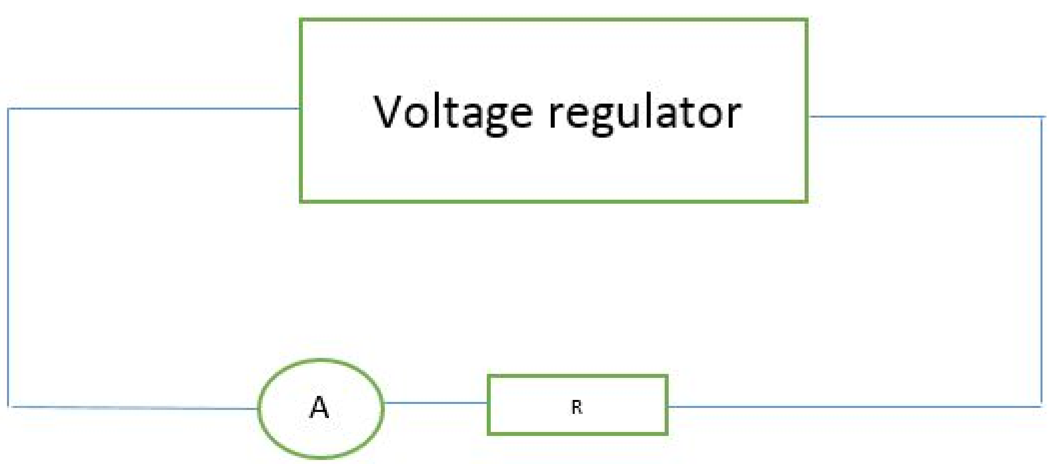
In order to get the highest efficiency the lowest value of Vcc allowed by requirement **3.10** in this verification plan was used. As the lowest value of Vcc (13.4V) would cause a roll off at the 12V output if its value dropped by 20%. Hence we had to use Vcc as 16.75V which gave us an efficiency of 51%. Note if we are able to get a battery with Voltage 13.4V which does not drop below that voltage we are able to get an efficiency of 63% which is within the requirements.

3.7 The digital power supply should have a voltage output between 4.85V-5.15V (Demonstration/analysis)

3.7.1 Verification Test

We would measure the output as we changed the input and see if the output stays between that limit. We also tested the circuit using resistors to allow a 5mA, 10mA and 20mA to check the range that the current can go through. For the 5V we used R = 250 Ohms, 500 Ohms and 1000 Ohms. We also performed corner analysis through numerical means.

Circuit diagram :



3.7.2 Verification Result

We found that it stayed between the values 4.85V - 5.15V for the 5V output. However we found when doing the corner analysis that our output voltages will vary between 4.60 - and 5.4. This is because we used resistor values which vary by 5 %. Using more accurate resistors will make out DC power supply more accurate for production.

3.8 Have a voltage output between 11.2V-12.8V as it is within the range required for the FLASH memory. The output current here should be 20mA (Demonstration)

3.8.1 Verification Test

We would measure the output as we changed the input from around 16.75V higher and see if the output stays between that limit. To check the 12V we used 590 Ohms, 1180 Ohms and 2360 Ohms to get currents of 5mA, 10mA and 20mA.

3.8.2 Verification Result

We found that it stayed between the values of 11.6V - 12.2V for the 12V output. However we found when doing the corner analysis that our output voltages will vary between 10.82 - and 12.5. This is because we used resistor values which vary by 5 %. Using more accurate resistors will make out DC power supply more accurate for production.

3.9 The single input voltage should not be within +/- 10% of either output voltage (Analysis)

3.9.1 Verification Test

We check by calculation that the value of Vcc calculated in requirement **3.10**. We check if varying the input Vcc coincides with the output voltage

3.9.2 Verification Result

As Vcc is 16.75V varying it by 10% gives us 13.4V which does not coincide with the outputs.

3.10 The system should maintain the output voltage specifications with an input voltage of +/- 20% from the nominal (Testing/Demonstration/Analysis)

3.10.1 Verification Test

In order to calculate the lowest possible value for Vcc +/- 20% for the digital power supply we found the smallest value input voltage for which the DC power supply provided reliable voltage outputs.
We then divide this by .8 to get the smallest value of Vcc for which a 20% drop in voltage will not cause errors on the output of the 12V supply.

3.10.2 Verification Result

We found that the lowest value Vcc can be 13.4 V so 13.4/.8=16.75V. Hence lowest value of Vcc +/- 20% is 16.75V.

3.11 Must use DipTrace for designing the PCB which is free & for non-profit use (Inspection)

3.11.1 Verification Test

We would use the software, by making sure it is downloaded on the diptrace website with a free license.

3.11.2 Verification Result

We found that it was produced in diptrace as we have produced .dip files which is a diptrace exclusive extension.

3.12 The PCB board should be doubled sided with a through hole plate so components will only be placed on the top side (Inspection)

3.12.1 Verification Test

Inspection of the PCB is enough to determine whether the circuit board is indeed double-sided with components placed on top. The existence of tracks on both top and bottom as well as the presence of vias reflects the double-sided nature of the board. The top side of the board should also have all the components

3.12.2 Verification Result

By examining the circuit board that we produced it is clear that both the conditions are met. Firstly there are tracks on both sides as well as vias and all the components are on the top side of the circuit board.

3.13 Surface mount components will be used of the package type 0805 (Inspection)

3.13.1 Verification Test

By using diptrace we make sure we use the right components through the discrete_smd library and select the 0805 components as well as this when making the PCB we make sure the components provided are the 0805 components.

3.13.2 Verification Result

We found that all components were the 0805 as specified.

3.14 Narrow range of regulators and DC-DC converters to choose from within the lab (Inspection)

3.14.1 Verification Test

The board should not have inductor regulators and/or DC-DC converters as specified in the brief. In order to verify that this is indeed the case, inspection of the chips on the prototype should be adequate to determine whether the components used are indeed from the range of components available in the lab.

3.14.2 Verification Result

By inspection we concluded that the prototype had indeed components from the ones available in the lab. Specifically, only µA723CD regulators were used to construct the board.

3.15 Board should have dimensions of 5cm x 5cm (Inspection)

3.15.1 Verification Test

Measurements of the dimensions were made using a mm scale ruler.

3.15.2 Verification Result

It was concluded that the board was indeed 5cm x 5cm.

3.16 The vias holes should be 0.8mm while the copper pads should be 1.6mm (Inspection)

3.16.1 Verification Test

Measurements of the diameter of the vias holes and the copper pads were made using a mm scale ruler. These values were set using the diptrace software.

3.16.2 Verification Result

We can see that the vias hole is 0.8mm and the copper pads are 1.6mm.

3.17 The holes for attachment of the wires/test pins should be 1.00mm while the copper pads should be 1.8mm (Inspection)

3.17.1 Verification Test

Measurements of the diameter of the test pins and the copper pads were made using a mm scale ruler. These values were set using the diptrace software.

3.17.2 Verification Result

We can see that the test pins are 1.0mm and the copper pads are 1.6mm.

3.18 The track width should be a minimum of 0.4mm (Inspection)

3.18.1 Verification Test

To ensure the 0.4mm track width requirement was met, we used the tools provided in the diptrace software.

3.18.2 Verification Result

We see that we set the track width to 0.4mm.

3.19 The track to track/track to pad separation should be a minimum of 0.4mm (Inspection)

3.19.1 Verification Test

To ensure the 0.4mm track to pad separation requirement was met, we used the tools provided in the diptrace software.

3.19.2 Verification Result

We find that the minimum distance is 0.4mm.

3.20 The Copper pour spacing should be 1mm (Inspection)

3.20.1 Verification Test

We make sure we set the spacing to 1 mm using the options available in diptrace.

3.20.2 Verification Result

We find that the spacing is 1mm.

3.21 The track/via/pad to board edge separation should have no tracks within 2mm of the edge (Inspection)

3.21.1 Verification Test

We could measure this using the in application ruler to manually measure the distance.

3.21.2 Verification Result

None of the tracks were within 2mm of the edge as specified.

3.22 Group number to be written in copper on the board on the top-side along the top (Inspection)

3.22.1 Verification Test

This feature was completed by writing the board code on the diptrace program.

3.22.2 Verification Result

The board code is printed on the board.